REMARKS

Status of the Claims

In view of the restriction requirement, which was made final in the present office action, claims 15, 16, 22-34, 54, 55-59 and 60-64 have been withdrawn from further consideration as being drawn to a non-elected species. Such withdrawal is without prejudice and applicant reserves the right to pursue such claims in subsequent divisional applications. Claims 1-14, 17-21, 35-53 are pending. Claims 1, 4, 9, 12, 41, 49, and 50 are currently amended.

Allowable Subject Matter

Applicants thank the examiner for indicating that claims 5-6, 8-12, 13 and 37-42 define patentable subject matter and would be allowable if rewritten in independent form including all of the limitations of the base claims and any intervening claims. Applicants also thank the examiner for indicating that claims 4 and 49-50 would be allowable if amended to overcome rejections under 35 U.S.C. § 112.

Claim Rejections - 35 U.S.C 112

Claims 4, 9-12, 41 and 49-50 currently stand rejected under 35 U.S.C. § 112 ¶2 as being indefinite. Applicant has amended such claims to more positively recite antecedent basis for the claim elements identified in the office action.

Abstract

In response to the objection to the abstract, applicants submit herewith a substitute abstract.

Specification

In the office action the disclosure was objected to for the recitation of "Memory 3 174." Referring to Figure 13, a number of memory elements are shown. Among these are Frame Memory 1 172, Frame Memory 2, 173 and Frame Memory 3 174. Thus, it is respectfully submitted that the portion of the description which was objected to is indeed proper. Reconsideration and withdrawal of the objection is respectfully solicited.

Claim Rejections - 35 U.S.C. § 102

In the office action, claims 35-36, 43, 44 and 48 have been rejected as allegedly being anticipated under 35 U.S.C. § 102(e) by U.S. Patent No. 5,828,793 to Mann. Applicants respectfully traverse this rejection.

Claim 35 is directed to a system for high dynamic range imaging which has, *inter alia* an array of light sensing elements having respective spatially varying sensitivities to incident light and corresponding photosensitivity values indicated of the respective photosensitivities. As discussed in the specification on page 24, lines 3-12, the use of light sensing elements having spatially varying sensitivities is an alternate solution to using light sensing elements in combination with a mask having a spatially varying exposure pattern. For example, the light sensing elements can be arranged in a 2x2 pattern of varying photosensitivities in a manner similar to that shown in Figure 4B, i.e., brightest cell, bright cell, dark cell, darkest cell. The photosensitivity pattern of the light sensing elements is stored in memory such that the values measured by the respective elements can be normalized.

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It is respectfully submitted that the Mann patent does not disclose or suggest the use of an array of light sensing elements having <u>spatially varying photosensitivities</u>, as defined by claim 35. The passage in Mann relied on in the office action (Col 7, line 44, Col. 8, line 16) does not disclose spatially varying photosensitivities, as that term is understood in the present application. Rather, Mann discloses a method of calibrating a substantially uniform array of light sensing elements which may have slight differences in sensitivity due to manufacturing tolerance, etc, using multiple exposures. Thus, Mann discloses a method of characterizing unintentional differences in sensitivity, which may or may not be present in a light sensing element, rather than use of an array of light sensing elements which are arranged in a predetermined manner to provide an organized pattern of spatially varying photosensitivities. Accordingly, Mann does not anticipate claim 35.

Claims 36 and 43 depend from claim 35 and are patentable over Mann at least for the reasons set forth above with respect to claim 35.

Claim 44 is directed to a method of high dynamic range imaging which includes, *inter alia*, the step of exposing an array of light sensing elements to an image of a scene using a <u>spatially varying exposure.</u> The spatially varying exposure can be achieved in a number of ways, such as by way of a mask that provides a spatially varying transmission of light or through the use of spatially varying photosensitivities, as discussed above with respect to claim 35. As discussed above, Mann does not disclose or suggest the use of spatially varying exposure. To the extent Mann discloses a varying exposure, it is in the context of a constant variation of the exposure level to the entire array over multiple exposures. In this regard, Mann discloses acquiring multiple images at multiple exposure levels in order to calibrate the light sensing

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elements of the array. However, Mann does not disclose the use of spatially varying exposure of a single acquired image in order to increase the dynamic range of an otherwise low dynamic range optical detector. Accordingly, Mann does not anticipate claim 44. As claim 48 depends from claim 44, Mann does not anticipate claim 48.

Claims 44 and 51 have been rejected as allegedly being anticipated under 35 U.S.C. § 102(e) as allegedly being anticipated by U.S. patent No. 6,501,504 to Tatko et al. Applicants respectfully traverse this rejection.

As discussed above, Claim 44 recites the use of spatially varying exposure. The Tatko et al. reference does not disclose the use of spatially varying exposure and, therefore, does not teach or suggest the subject matter set forth in claim 44. As illustrated in Figure 1, Tatko et al. employ an optical attenuator disposed between an optical image 12 and a sensor 18. The attenuator 14 is described as adjusting the integration constant for a CCD device or adjusting the iris setting in a digital camera. (See Col. 3, lines 9-18). The attenuator 14 uniformly varies the exposure to the entire sensor 18 to effectively vary the gain of the entire sensor array. Tatko et al. do not disclose the use of attenuator 18 to introduce a spatially varying exposure, as set forth in Claim 44. Accordingly, Tatko et al does not anticipate claim 44 of the present application. Claim 51 depends from claim 44 and is allowable over Tatko et al. at least for the reasons set forth above.

Claim Rejections - 35 U.S.C. § 103

Claims 1-3, 7, 14 and 17-20 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over the '793 patent to Mann in view of U.S. published application 2002/0050518A1 to Roustaei ('518). Applicants respectfully traverse this rejection.

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The Mann '793 patent is discussed above. In the office action, it is acknowledged that Mann '793 does not disclose "a mask...having a multiplicity of light transmitting cells each controlling the exposure of a respective one or more of the light sensing elements...." The office action looks to Roustaei '518 for this limitation.

Claim 1 has been amended to more particularly point out that the multiplicity of light transmitting cells are arranged to provide for spatially varying exposure of the array of light sensing elements. It is respectfully submitted that claim 1, as amended, is patentably distinct from the art of record.

As noted above, Mann '793 does not teach or suggest the use of spatially varying exposure as a mechanism to increase the dynamic range of an array of light sensing elements. To the extent that Roustaei '528 discloses the use of a mask with a multiplicity of cells, such a mask is a conventional color filter used for color separation of color images, such as a Bayer mask. (See Figs. 67, 68). The masks disclosed in Roustaei '528 do not provide for a spatially varying exposure of the array of light sensing elements in order to increase the dynamic range of a low dynamic range sensor. Further, it would not be practical to attempt to modify the teachings of Roustaei '528 or Mann '793 in an effort to arrive at the presently claimed invention. As Roustaei is directed to color separation, in order to combine this work with Mann to achieve high dynamic range one would need to understand both the spectral response function of the sensor as well as the spectral characteristics of the incident light, which is unknown. As neither reference discloses the mask set forth in amended claim 1, the combination of these references fails to teach or suggest the claimed subject matter. Accordingly, it is respectfully submitted that claim 1, as amended, defines patentable subject matter over Mann in view of Roustaei.

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Claims 2-3, 7, 14 and 17-20 each depend from claim 1, directly or indirectly, and therefore are patentable over Mann in view of Roustaei at least for the reasons set forth above.

Claims 1 and 21 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over the '793 patent in view of U.S. Patent No. 6,124,974 to Burger. Applicants respectfully traverse this rejection.

It is respectfully submitted that Burger does not teach or suggest spatially varying exposure in order to increase dynamic range of an image. Accordingly, the combination of Mann and Burger does not teach or suggest the subject matter of claim 1 or any of the pending claims. In the office action, Burger is relied on for its disclosure of a mask having a multiplicity of light transmitting cells. . .." As amended, claim 1 further recites that the multiplicity of light transmitting cells provide spatially varying exposure to the array of light sensing elements.. Burger does not disclose this claim element. Furthermore, Burger is directed to a "lenslet array" for magnifying and demagnifying images. Burger does not address the claimed subject matter of increasing dynamic range of an imaging sensor. Accordingly, Burger does not address the shortcomings noted above with respect to the Mann patent as applied to claim 1, as amended. Claim 21 depends from claim 1 and is allowable at least by reason of such dependency.

Claims 45, 46, 47 and 52 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over the '793 patent in view of U.S. Patent No. 5,373,322 to Laroche et al.. Applicants respectfully traverse this rejection.

As set forth above with respect to Claim 44, it is respectfully submitted that Mann '793 does not teach or suggest spatially varying exposure, as set forth in claim 44. The '322

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patent to Laroche et al. does not provide the missing teachings required to render claims 45, 46, 47 and 52 unpatentable. The mask referred to in Laroche is a well known Bayer geometry mask for color separation. The Bayer mask is also disclosed in Fig. 68 of Roustaei, which is discussed above. The Bayer mask does not achieve spatially varying exposure to increase dynamic range as set forth in the present claims. Rather, the Bayer mask is a pattern of green, red and blue filters arranged such that each pixel is responsive to all three colors. Selective filtering of different bandwidths of light as takes place in the Bayer mask does not suggest spatially varying exposure to an imaging array, as presently claimed. Accordingly, favorable consideration of claim 45 is respectfully solicited.

Claims 46, 47 and 52 depend from claim 45 and are patentable at least by reason of such dependency.

Conclusion

In view of the amendments and remarks set forth above, favorable consideration and allowance of Claims 1-14, 17-21, 35-53 are respectfully solicited. If for any reason the application is not deemed in condition for allowance, the Examiner is invited to contact the undersigned in order to advance the prosecution of this case.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

Apparatus and methods are provided for obtaining high dynamic range images using a low dynamic range image sensor. The image of a scene is captured with an image sensor using a spatially varying exposure function. The spatially varying exposure function can be implemented in a number of ways, such as by using as an optical mask with a fixed spatial attenuation pattern or by using an array of light sensing elements having spatially varying photosensitivities. The captured image is then normalized with respect to the spatially varying exposure function. The normalized image data can be interpolated to account for pixels that are either saturated or blackened to enhance the dynamic range of the image sensor.

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